Mass Physical and Geochemical Properties of High Latitude Sediments: European Arctic

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LONG-TERM GOALS

Our long-term goals are to use mass physical properties measured in a suite of Arctic Ocean sediments cores combined with the sediments' mineralogical and chemical compositions to obtain insight into present and past sedimentary processes in high latitude deep-sea (>200 m depth) depositional environments. Over the longer term we will use mass physical properties of sediment to conduct ground truth studies of seismic stratigraphic records of glacial marine facies from a variety of high latitude, cold climate environments. We will also use the chemical attributes of the sediment cores to assess the health of the environmentally sensitive Arctic region studied with respect to potentially toxic metals/metalloids.

OBJECTIVES

Determine the relationship between the mass physical properties and the acoustic behaviour of unconsolidated sediments in the Arctic regime.

2. Use the mass physical properties of the sediments 1) to allow better geotechnical mapping of portions of the Arctic sea floor and in this way characterize zones of sediment instability; 2) to evaluate seafloor conditions for various offshore construction projects; 3) to conduct evaluations of mass sediment movement phenomena.
3. Identify the chemical character of certain sedimentary environments of deposition and establish the presence of pollution concentrations of potentially toxic metals that could affect Arctic ecosystems in the Kara Sea and adjacent seas.

APPROACH

We have in our possession several datasets obtained through the analysis of glacial-marine sediments from a variety of high latitude environments including the Kara Sea and a number of Baffin Island fjords, Baffin Bay. The sedimentological data assembled include wet unit weight (bulk density), water content, specific gravity of the solids, void ratio, porosity, Atterberg limits and indices, minerological (quartz, plagioclase feldspar, illite, chlorite, kaolinite and smectite) and textural analysis. We also generated geochemical data including major elements, transition elements and potentially toxic elements followed by the Arctic Monitoring and Assessment Program.

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The data have been evaluated using a statistical program to generate descriptive statistics. In addition, multivariate statistics such as regression analysis, Q and R mode factor analysis, and cluster analysis were used to reveal interrelations among the physical, chemical and mineralogical variables in our data set.

These data have been used in combination with oceanographic data on surface and bottom current flowpaths and information on land geology to better understand the relationships between them and sediment characteristics in the high latitude depositional environments.

WORK COMPLETED

During the latest period of the grant, Oct. 1, 1998 - Sept. 30, 1999, the mass physical properties of Kara Sea sediment cores have been analysed statistically using down-core Q mode factor analysis. In addition, we completed the geochemical analyses on the 31 cores from the St. Anna Trough which represent 276 samples. The analyses were for a suite of 40 elements. This completed the geochemical data set which also includes 86 samples from 8 cores from the Novaya Zemlya Trough, and 113 samples from 14 sediment cores from the Voronin Trough. These data have been combined with the textural data and a part of the mineralogical data and have been evaluated using the statistical analyses cited previously. The data have been further assessed using knowledge of the surface and bottom current flowpaths by which entrained sediment is transported to the Kara Sea troughs. The sediment sources have been evaluated using information on land geology and the fluvial systems that discharge into the Kara Sea.

RESULTS

The Kara Sea sediment cores' chemistry showed that surface/near surface sediments in the East Novaya Zemlya troughs have contamination levels of arsenic and mercury, potentially toxic elements to Arctic Ocean ecosystem life forms. The contamination levels are very high when compared to baseline concentrations from sediments deep in the cores that represent pre-industrialization time. The other potentially toxic elements tracked by the Arctic Monitoring and Assessment Program are at baseline levels throughout the cores studied.

The provenance of the contaminants is believed to be from anthropogenic activities such as burning of fossil fuels for electricity generation and heating, mining and smelting of ore minerals, industrial activities, and the disposal of military material at ocean dump sites. The industrial activities that generate the pollutant metals are at industrial complexes in the Western Siberian Plain, in the Eastern Urals, from the Novaya Zemlya archipelago, and there likely is some input from the Kola Peninsula. The contaminants are moved by ocean currents to depositional environments adsorbed to particulates (arsenic to iron oxy/hydroxides and mercury on organics or clay minerals) found both in seawater and pack ice. The contaminants originate from atmospheric emissions and deposition in drainage basins of the rivers that discharge into the Kara Sea and as effluents released from industries into the fluvial systems of these rivers.

IMPACT/APPLICATIONS

The data from this research is directly relevant to the Navy's interest in the Arctic and has the potential of a direct transition to operational requirements. In relation to the civilian sector, it has application to several integrating themes of the Global Change program as well as to ocean environment programs

concerned with pollutant distributions in the Arctic seas. These pollutants include potentially toxic metals/metalloids, organic compounds and radionuclides. It may be possible to identify former Soviet Union chemical weapons dump sites using arsenic in sediments as a pathfinder to dump sites that contained Lewisite.

PUBLICATIONS AND PRESENTATIONS COMPLETED DURING THE LATEST PERIOD OF THE GRANT:

Galasso, J.J., Siegel, F.R. and Kravitz, J.H., in press. Heavy Metals in Eight 1965 Cores from the Novaya Zemlya Trough, Kara Sea, Russian Arctic, Marine Pollution Bulletin

Siegel, F.R., Galasso, J.J., Kravitz, J.H. and Basinger, W.D., in press The Svalbard western coast: site of baseline geochemistry and incipient contamination, Environmental Geology.

Siegel, F.R., Kravitz, J.H. and Galasso, J.J., in press, Arsenic and mercury in thirteen 1965 cores from the Voronin Trough, Kara Sea, European Arctic, Applied Geochemistry.

Siegel, F.R., Kravitz, J.H. and Galasso, J.J., in press. Arsenic in arctic sediment cores: pathfinder to chemical weapons dump sites? Environmental Geology.

Siegel, F.R., Kravitz, J.H. and Galasso, J.H., 1999. Baseline and high value (pollutant?) concentrations of metals/metalloids from 50 cores in Kara Sea Troughs' sediment, European Arctic (Abs.), presented at the 2nd Conference of Environmental Geochemical Baseline Mapping in Europe, Vilnius, Lithuania, in Abstracts Book, pp. 87-88.

Siegel, F.R., Kravitz, J.H. and Galasso, J.J., 1999. Contaminant and baseline concentrations of potentially toxic elements in fifty-one cores from Kara Sea Troughs, European Arctic: As, Hg and others (abs.). Oral presentation at the Annual Meeting of the Geological Society of America, October 26, Denver.

Siegel, F.R., Kravitz, J.H. Galasso, J.J., Basinger, W.D. Ivanov, G.I. and Krylov, A.A., 1998. Geochemical attributes of western shelf sediments, Svalbard: a contrast with Kara Sea trough sediments (abs.). Oral presentation at the Annual meeting of the Geological Society of America, October.

IN PREPARATION:

Siegel, F.R., Kravitz, J.H. and Galasso, J.J., Arsenic and Hg contamination in thirty-one 1965 cores from the St. Anna Trough, Kara Sea, European Arctic. 95% complete.

IN PROGRESS:

Kravitz, J.H. and Siegel, F.R. The clay-size contribution and mineral suite in Kara Sea Troughs sediments: influence on mass physical properties and pollution loading.